# Gas Journal

VOL. 303 | 112th YEAR | LONDON, AUGUST 3, 1960 | No. 5057 | PRICE 1/6



THE UNIVERSITY OF MICHIGAN
AUG 30 1960
ENGINEERING LIBRARY

**there's more than tradition in a T.G. meter**

**THOMAS GLOVER & CO. LTD.** *Works and Branches at* ACTON · BELFAST · BRISTOL · CARDIFF · DUBLIN EDINBURGH · EDMONTON · GLASGOW · MANCHESTER · NEWCASTLE and OLDHAM

T.G.50

# CROSSLEY GRIDS

*for*

**PURIFIERS, SCRUBBERS and WASHERS**

★ **Embody the latest improvements**

★ **Very best quality**

★ **Used extensively throughout the United Kingdom**

*Enquiries welcomed for any kind of Grid.*

## CROSSLEY BROTHERS,

**STATION WORKS, BLACKPOOL**

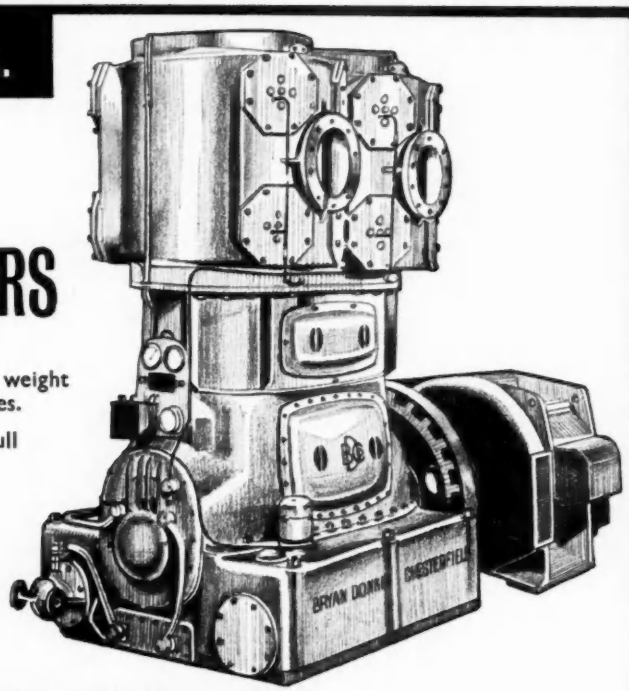
**Telephone: BLACKPOOL 51005/6** **Telegrams: WOODWARE, BLACKPOOL**

## DONKIN TYPE 300/A.

# VERTICAL RECIPROCATING COMPRESSORS

**FOR AIR & GASES**

- Drop forged connecting rods, give improved weight strength ratio and reduction in unbalanced forces.
- Precision manufactured shell bearings ensure full inter-changeability without fitting.
- Light alloy frame doors of generous dimension give easy access to interior.
- Centrifugal oil filter and cooler are integral part of the compressors.
- Compressors can be supplied in weatherproof construction for outdoor installation.

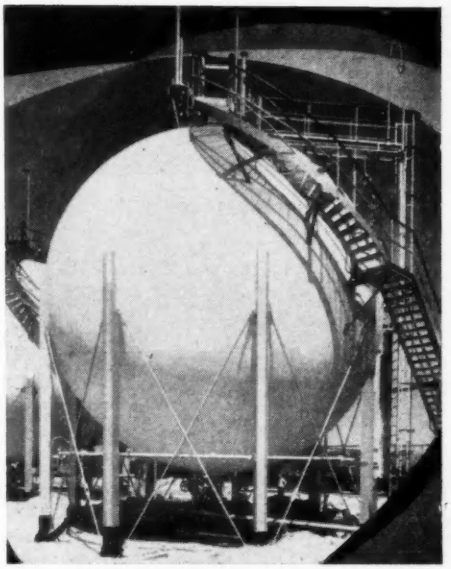



**FOR SINGLE, TWO OR THREE STAGE COMPRESSION**

**THE BRYAN DONKIN COMPANY LIMITED** TELEPHONE 3153 (6 lines)

CHESTERFIELD • LONDON AND TORONTO

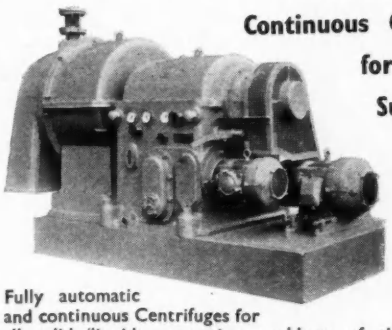
M·A·N



Spherical vessels for storage of gases and liquids under pressure.

Pressure tanks and containers of every description for the gas, oil and chemical industries.

M. A. N. plant and equipment are being manufactured in the United Kingdom, to the design and specifications of M. A. N.



**Continuous Centrifuges for Sulphate of Ammonia**

Fully automatic and continuous Centrifuges for all solids/liquids separation problems of the gas, oil and chemical industries.

**also Vacuum and Pressure Filters and Driers**

KRAUSS MAFFEI IMPERIAL GmbH
MUNICH

*Both M.A.N. and K.M.I. are represented by :*

W. WYKEHAM & CO., LTD
17-19 COCKSPUR STREET · LONDON · S.W.1
Cable address: "WYCOTRAF" Telephone: WHItehall 5307
TELEX : 22448

*Research Laboratories :*
AEON Laboratories, Ridgemead Road, Englefield Green, Surrey



# Gas Journal

VOLUME 303 • NUMBER 5057 • 112th YEAR

WEDNESDAY, AUGUST 3, 1960

## CONTENTS

### *EDITORIAL COMMENT*

Bacteria in Gasholder Tanks - - - - - 157
Diesel Engines in Gasworks - - - - - - 158

### *SPECIAL ARTICLE*

The Sulphur Cycle in the Gas Industry. By B. E. Purkiss - - - - - - - - - - 159

### *TECHNICAL RECORD*

Diesel Engines in the Gas Industry. By A. J. Ingram 162
Natural Gas Powers U.S. Air Conditioning System - 172

### *NEWS SUPPLEMENT*

Commons Will Keep a Close Watch on Public Spending - - - - - - - - 173
More Pay for Gas Staffs - - - - - - 173
World's Largest Radiant Heating System - - 173
Fuel Availability in United Kingdom - - - 173
Scottish Board Abolishes Standing Charge - - 173
Oxygen Plant at Corby - - - - - - - 174
Mexico-U.S. Pipeline - - - - - - - 174
Personal - - - - - - - - - 175
Company News - - - - - - - - 175

### *GAS IN INDUSTRY SUPPLEMENT*

Editorial: North Western Exhibition - - - 205
Scotland's Industrial Gas—II. By A. Higgs and R. W. Deans - - - - - - - - - - 206
H. P. Lupton's New Treatise on Industrial Gas Engineering. Review by Dr. H. Alex. Fells - 215
The Servicing of Industrial Catering Equipment. By 'GAStronome' - - - - - - - - 216

*Editor :*
GEOFFREY W. BATTISON

*Technical Editor :*
CHARLES J. P. DE WINTON,
T.D., M.A., M.Inst.Gas E., M.Inst.F.

*PUBLISHERS' NOTICE, SEE PAGE 177*

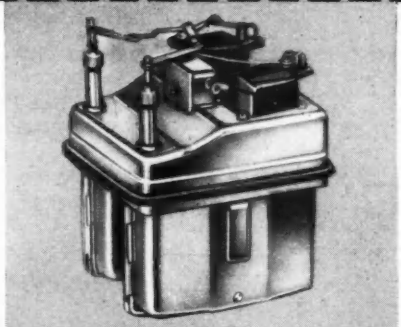
PARKINSON COWAN

# LEADERS BY DESIGN...

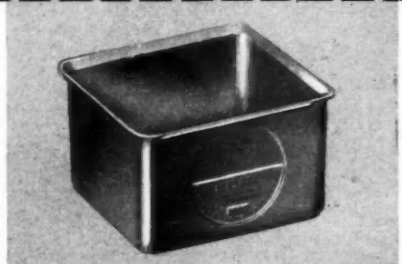
Zephyr Type 219

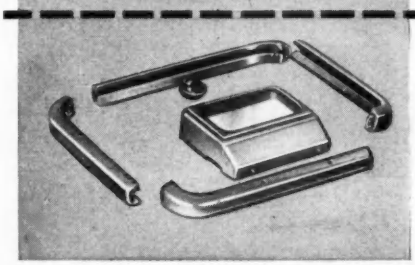
Zephyr Type 218

## Endorse UNIT CONSTRUCTION



Gas meter maintenance can be expensive.
UNIT CONSTRUCTION cuts the cost by saving time and labour.
The Parkinson Cowan Zephyr is unit-constructed. Its two-part steel case can be dismantled within seconds to give immediate access to the removable measuring unit.
Economise by design . . . with UNIT CONSTRUCTION.





## PARKINSON COWAN GAS METERS

Terminal House, 52 Grosvenor Gardens,
London, SW1 SLOane 0111

# Gas Journal

COKE OVENS • BY-PRODUCTS • CHEMICALS

## *Bacteria in gasholder tanks*

THE part played by bacteria in many natural processes not commonly connected with any form of organism, is becoming increasingly recognised. Corrosion of cast iron pipes laid in certain soils, and other metal work, a process which would appear to be a purely inorganic chemical reaction, has been found to be connected with bacterial action. The discovery of a sulphur cycle in nature depending for its motive power on bacterial action—similar perhaps to the nitrogen cycle in plants—was a step forward in the understanding of the mechanism of certain changes involving sulphur oxidation and reduction occurring in nature.

It might seem a far cry from the sulphur cycle to the fouling of gasholders by the spontaneous evolution of hydrogen sulphide, but it has been known for a long time that some form of bacteria was indeed responsible for this most embarrassing state of affairs. The position can be easily imagined when a holder of purified gas is rendered virtually useless by the generation of hydrogen sulphide in the holder water.

The mechanism of this reaction does not seem to have been completely understood in the past, and purely inorganic reagents were used in comparatively large quantities to recondition the water. This was both expensive and unsatisfactory since any advantage gained was found to be purely temporary.

An account of an investigation into the causes of the spontaneous generation of hydrogen sulphide under such conditions and its prevention by Mr. B. E. Purkiss, of the British Drug Houses Ltd., appears in our current issue.

The observed facts—some of them were most baffling—showed the author that the solution of the problem was essentially one for the use of a bactericide, and when this had been established, a special reagent known as Panacide was manufactured by his firm to meet the case.

The fouling mechanism is one of conversion of certain inorganic sulphur compounds (sulphates) in the water to hydrogen sulphide by a particular bacteria; similarly hydrogen sulphide may be oxidised to sulphuric acid by other bacteria.

The life and habits of the bacteria were carefully studied and showed that their activities were curtailed by the presence of their own waste products above a certain concentration. If, however, this concentration was reduced to below the critical amount, they became active once more.

The author's account of this enquiry shows how rewarding a patient and exhaustive investigation can be. Not only was it necessary for him to do a considerable amount of laboratory work, but also to carry out much patient field work on troublesome gasholders themselves.

Why should this effect in a large capacity holder suddenly cease and equally suddenly become active again? Investigation showed that the necessary bacteria remained in the bottom of the tank, in fact bacteria have not been found higher than 7 ft. from the bottom. Great activity on their part raises the concentration of the hydrogen sulphide to the critical point and further activity ceases. A reduction in this concentration would clearly cause a renewal of activity. Atmospheric temperature changes will cause inversions in the holder tank, and a considerable dilution of the hydrogen sulphide concentration will be the result. Such is the mechanism of the activity cycles.

The author's task was now to find a suitable bactericide, but first of all he reviews the older treatments hitherto applied to gasholder tanks, and shows how these fall short of the complete eradication of the basic trouble.

Oxidation, precipitation and starvation are the three treatments which have been used in the past. They have been unsuccessful for two particular reasons. They all attempted to reduce, even eradicate, the inorganic sulphur compounds without getting rid of the bacteria, the active agents, and, since it was impossible to get rid of these compounds permanently, all treatments could only be a palliative.

In every case, a reduction in hydrogen sulphide concentration would renew the activity of the bacteria, and the high concentration of some of the reagents might well cause corrosion of the holder itself. The starvation technique by which the entire sulphate content of the water was supposed to have been removed by the bacteria which would then die, involved keeping a holder idle for as long as two years without any guarantee that it had in fact been 'cured.' It was far more likely that the bacteria had multiplied during their activity and after reverting to the quiescent state, would

be ready for renewed activity at the first appearance of any sulphate.

Experiments have shown that the Panacide treatment has been successfully applied to a number of troublesome holders. This is a great step forward, and if it should prove the solution to all such holder troubles, an apparently insoluble problem has at last been surmounted.

# *Diesel engines in the gasworks*

THE widespread use of diesel engines for specialised application by the gas industry is comparatively new, so new in fact that we cannot recall seeing such engines in any number before nationalisation. In the last few years, however, they have been adopted on an increasingly large scale to drive compressors, boosters, and auxiliary generators.

The actual number in use varies considerably from board to board, but works and holder stations remote from steam or electricity services are more likely to adopt this form of prime mover than those in more developed and built-up areas. It was perhaps not surprising, therefore, that this week's paper on the use of diesel engines in the gas industry by Mr. A. J. Ingram should come from the South Western Section of the Institution.

Mr. Ingram, who until recently was the area diesel engineer of the South Western Board, refers particularly to installations in Devon and Cornwall. In these localities the use of diesels for compressors may have certain advantages over the now familiar electrically driven machines. It is noteworthy, however, that the advantages of diesel drive are being more widely recognised, all the more so, perhaps, because of the tendency to substitute oil for coal in gasmaking. If this tendency continues and very large quantities of gas are produced from refinery products, it seems likely that greater use will be made of these same refinery products for steam raising and power requirements. Besides, in addition to being very reliable and reasonably flexible, the diesel engine will probably be cheaper to run. Its application to holder stations illustrates the diesel engine's advantages, especially if it can be started by remote control.

The diesel engine then has come to stay and may find uses in the gas industry additional to those common in most other industries. Diesel shunting engines and diesel-driven portable conveyors, stackers and shovels are as common in the large gasworks today as they are in any other factory of similar size, but diesel-driven ancillary gasworks plant appears to be slowly gaining in popularity.

Does this mean that there has been a subtle shift in policy from the all-electric gasworks which was considered the latest thing at the time of nationalisation? Is the desire to be self supporting in power, and to be independent of the electricity boards except as a customer for surplus power, impractical?

The all-electric gasworks may have run into difficulties, but it is clear that the thermally integrated works is an excellent proposition. Whether the waste-heat steam is to be directly converted to electrical energy or used in the individual works' prime movers, is a matter to be decided by the designers of the works, and is influenced by the relative costs ruling in the particular locality at the time.

A balance for the most efficient use of this steam can be and is found, and the outstanding works' needs for power can be made up either by electricity from the grid or local generation by a suitable diesel-driven set. The use of diesel power for gas transmission into the grid system depends, therefore, on the relative availability of other power and its cost. It would be common practice then, on the modern works comprising carbonising and oil gasification plant, to find the diesel drives as standby to steam- or electrically-driven compressors, but in every case we would expect to see either steam or electrically driven exhausters and ancillary pumps.

Mr. Ingram's paper is timely since it puts the case for the diesel engine clearly and objectively and leaves the gas engineer to draw his own conclusions as to its suitability for his individual needs. As far as we know this has not been done in a paper before, and so the value of it as a source of information is considerably enhanced. It deals in considerable detail with the advantages of the main types of diesel available; the two- or four-stroke, the air- or water-cooled. Such divisions into types may perhaps be equally well applied to petrol engines, but it is quite clear from the paper that we are dealing here with something quite different. The types of fuel are also discussed, and the paper shows how the standard of diesel fuel—the 'cetane' number—is arrived at.

It is most interesting to see how very reliable this type of prime mover is and that, although cylinder wear has to be watched most carefully, diesel engines can run for long periods without fear of breakdown; in fact in one case given, a compressor had run for over 22,500 hours out of a total possible of a little over 26,600 hours. When stripped this particular engine showed remarkably little wear.

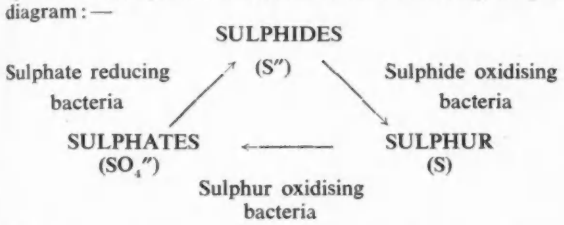
On the question of maintenance, it appeared that a gas board fitter after instruction was perfectly capable of changing cylinder heads and doing other necessary maintenance work. Perhaps additional training under the manufacturers' fitter might be necessary before the local man was capable of carrying out a complete overhaul, but it is most reassuring to see his potentialities. Since diesels need a somewhat higher standard of workmanship than do the corresponding steam engine, Mr. Ingram advises that works fitters should attend courses at the manufacturer's works. This is clearly of advantage to the board and excellent for the man's self-confidence. The cost of training is small compared with that to be gained from conscientious and skilful maintenance on a fairly complicated machine.

Strange though it may seem, oil has once more 'muscled in' on gasworks' practice, and is supplanting a traditional form of power. This may not be a serious intrusion but it may well be symptomatic of present trends.

# The sulphur cycle in the gas industry

BY B. E. PURKISS, A.I.L., M.T.I., M.I.Biol.

THE contamination of gas with hydrogen sulphide formed by sulphate-reducing bacteria in holder sealing water is a problem familiar to gas engineers. Another industrial problem is that of corrosion by sulphur-oxidising bacteria. The two problems are linked, since the activities of these bacteria form part of the 'sulphur cycle'. This cycle is illustrated in the following simple diagram:—




Several species of bacteria are able to generate hydrogen sulphide from sulphates, the most widely distributed being *Desulphovibrio desulphuricans.* These bacteria derive their necessary oxygen and energy by converting sulphates into sulphides and oxygen. Hydrogen is then required to convert the sulphides into hydrogen sulphide, and may be obtained from various sources. It may, for example, be present in the 'nascent' state, formed during metallic corrosion processes. The bacteria also require organic matter, and this is usually abundantly present in gasholder water. *D. desulphuricans* occurs widely in soils and surface waters, so it is unlikely that any gasholder would escape inoculation, although the bacteria may not thrive in every case. Sulphate-reducing bacteria are remarkably adaptable, forming strains able to withstand a wide range of unfavourable conditions. They require very little sulphate to sustain growth: In favourable conditions, concentrations as low as 2 ppm. are quite adequate for vigorous growth.

## Sulphur-oxidising bacteria

Sulphur-oxidising bacteria, responsible for the remaining part of the sulphur cycle, catalyse the formation of sulphuric acid from hydrogen sulphide, sulphur or thiosulphate. Species of the *Thiobacillus,* especially *Th. thioparus, Th. thiooxidans* and *Th. concretivorus* are widespread, and their activities cause a large amount of damage to industrial property each year. Thiobacilli are able to endure very acid conditions. Most will, in fact, grow quite readily at a *p*H of 1, although this condition does not often occur since the sulphuric acid they produce is neutralised as it is formed by surrounding material.

Ymonet established that water contained in the holder tank was a source of hydrogen sulphide, which was then picked up by the gas. He suggested treatment with ferrous sulphate to remove dissolved hydrogen sulphide as ferrous sulphide, but this remedy is now known to be quite inadequate.

Published work by Taplay, Bunker, Butlin and Evans showed that the hydrogen sulphide is generated by *D. desulphuricans.* These bacteria are motile and might be thought to be dispersed throughout the whole body of the water. They are, however, anaerobic and thrive only in the oxygen-deficient lower layers of water at the bottom of the holder tank. We have seldom found *D. desulphuricans* more than 7 ft. from the bottom of the holder tank.

Conditions in holder water are quite adequate for the growth of *D. desulphuricans,* although not optimum. As the number of bacteria increases, so does the concentration of hydrogen sulphide in their vicinity. The rate of growth of bacteria depends on, among other factors, the extent to which their waste products are allowed to accumulate around them. When a certain concentration of these products is exceeded, the rate of growth decreases and a state of unstable equilibrium is produced.

## Hydrogen sulphide trapped

As hydrogen sulphide is generated, it is trapped or absorbed by sludge particles on the floor of the holder. If the local concentration of hydrogen sulphide is too high, the activity of the bacteria decreases until they pass into a dormant state and hydrogen sulphide is no longer produced. Should this local concentration of gas be reduced, then the bacteria resume generating hydrogen sulphide. This may be caused by 'thermal inversion'. When a sudden frost or a severe fall in temperature occurs, the cooler, denser surface water sinks and convection currents are set up. The sludge at the bottom of the tank is disturbed and the absorbed hydrogen sulphide is given off. The consequent local reduction in hydrogen sulphide concentration allows the bacteria to produce further quantities of gas. Study of over 100 gasholders has shown that many apparently uninfected holders are potential generators of hydrogen sulphide.

Methods which have been used to prevent hydrogen sulphide contamination in water-sealed holders, fall into four groups.

1. *Oxidation.* The use of chlorine, hypochlorites, hydrogen peroxide and aeration has been suggested, but they all have serious disadvantages. Sulphides present may be oxidised to sulphates and we have already seen that the removal of local excesses of sulphides may stimulate dormant sulphate-reducing bacteria to renewed growth. The presence of unchanged oxidising agents in the surface water may favour the multiplication of the sulphur-oxidising bacteria. The oxidising agents may cause corrosion. The normally substantial quantities of organic matter in holder water consume further amounts of oxidising agent, so that on achieving suppression of the bacteria, the electrolyte concentration may be undesirably large.

Other disadvantages of this method are the need for frequent determinations of the amount of dissolved solids and the B.O.D.—biochemical oxygen demand—both time-consuming and laborious operations.

Chromic acid has been used as an oxidising material. We understand that T. A. Dick, of the West Midlands Gas Board, has achieved worthwhile results, and has studied means of avoiding corrosion. Such treatment, however, would require a source of waste chromic acid, otherwise the cost would be prohibitive.

2. *Precipitation.* This method seeks to remove hydrogen sulphide as an insoluble sulphide, thus preventing pick-up by the gas. Ferrous sulphate, zinc acetate, zinc oxide, copper sulphate and barium chloride have been recommended.

The addition of ferrous sulphate is open to the objection that the sulphate content of the water is increased, providing more food for the sulphate-reducing bacteria. Addition of zinc acetate or zinc oxide does not introduce sulphate ions or increase the total sulphur content of the holder. But these additions could stimulate dormant sulphate-reducing bacteria to fresh activity, since they remove the inhibiting hydrogen sulphide.

The solubility of zinc sulphide is 6.9 ppm., and this level is quite sufficient to enable thiobacilli to grow on the surface water. The thiobacilli then convert the sulphide to sulphate. It is usual to maintain a constant level of 3 ppm. of zinc in solution, on the assumption that this apparent excess ensures protection. Probably, however, the zinc determined is present as dissolved sulphide.

The value of copper sulphate as a bactericide under the conditions in a gasholder is doubtful. It has the disadvantages, already mentioned, of ferrous sulphate or zinc acetate, but the most telling argument against its use is the danger of galvanic corrosion.

## The barium chloride method

The barium chloride method has as its object the removal of dissolved sulphates by precipitation as barium sulphate, thus preventing subsequent reduction to sulphides. But the very small amount of barium sulphate remaining in solution is quite adequate to sustain *D. desulphuricans.*

3. *Starvation.* This procedure, which allows bacterial activity to continue until all the sulphates are reduced and, in theory, all the bacteria die, is open to the most serious criticism. It necessitates having a holder out of service for some months, and the disposal of the contaminated gas. In the interval between the onset of the trouble and the point when growth ceases due to consumption of all available sulphate (or to a local excess of hydrogen sulphide (the number of bacteria may have increased a thousand-fold. If infection by bacteria capable of oxidising sulphides to sulphate occurs and sulphates again become available to the sulphate-reducers, then the bacterial problem is now much more serious that that initially presented. Considering, too, that the holder water is continuously exposed to contamination with sulphur oxides from atmospheric pollution, the method is seen to be completely unreliable. There is little doubt that the trouble will recur, probably in an aggravated form.

4. *The use of bactericides.* It will now be obvious that the only course of treatment likely to yield lasting success is to kill the sulphate-reducing bacteria. The Panacide method is the first bactericidal method to have gained widespread acceptance by the gas industry.

Work in the laboratories of The British Drug Houses, Ltd., later confirmed at the Department of Scientific and Industrial Research at Teddington, has shown that Panacide at 5 to 6 ppm. in holder water controls the growth of *D. desulphuricans.* Panacide for gasholder treatment is supplied as a 40% w/v solution of its mono-sodium salt in water and has a specific gravity of 1. .

The bactericide is added as a lower layer to the holder water by means of a hose pipe reaching to the floor of the tank. In contact with water of *p*H less than 7.8 the mono-sodium salt hydrolyses and the sparingly-soluble Panacide is precipitated and forms a reservoir of bactericide. This 'layering' technique gives the treatment a greatly extended life. The treatment is not corrosive to metals nor is it poisonous. The bactericide will not, of course, remove hydrogen sulphide dissolved in the water. It is recommended that any dissolved $H_2S$ be precipitated with zinc acetate before addition of the Panacide. Zinc acetate treatment is not necessary when sulphide-free water is used in newly commissioned gasholders.

## Panacide added to gasholder

M. J. P. Le Cornu has reported the results obtained when Panacide was added to a large gasholder at Fulham. The water, which had an initial sulphate content of 4.7 grains per gal., was treated with 5.5 ppm. of Panacide in November 1958. No significant increase in the hydrogen sulphide level of the water took place during the next 12 months, although by May the next year the sulphate level had reached 6 grains per gal., due probably to atmospheric pollution. A maintenance dose of 1 ppm. of Panacide was added in October 1959 as a precautionary measure, and the holder water continues to give satisfactory hydrogen sulphide levels. Of especial interest in this case is the good control achieved, although the Panacide was distributed evenly throughout the water as opposed to the method

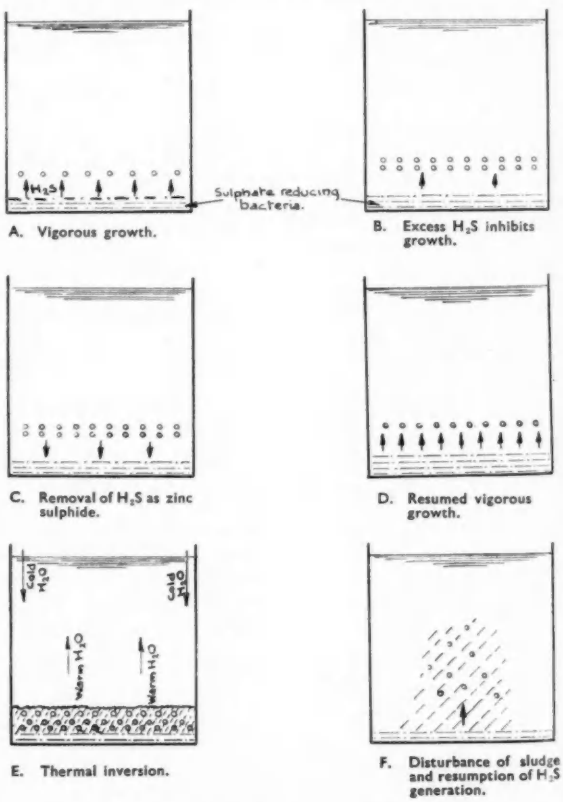



*Fig. 1.—The effect of the various conditions inside a gasholder tank on the production of hydrogen sulphide.*

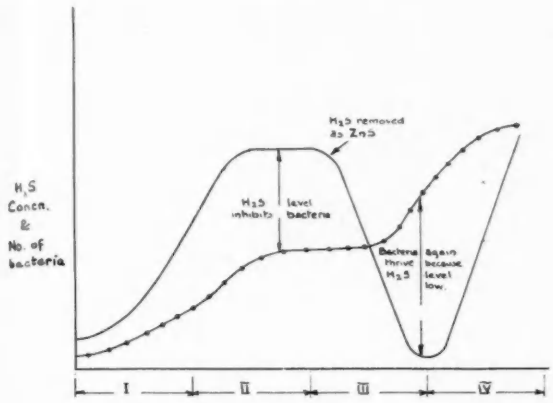



*Fig. 2.—The effect on bacterial activity on reducing the hydrogen sulphide concentration by precipitating the surface as ZnS.*

described above, where the Panacide solution is 'layered' at the bottom of the holder tank.

L. G. Townsend discussed in his paper 'Some Aspects of Water Treatment' delivered to the Manchester District Junior Association of Gas Engineers in February this year, the results obtained over three years on a gasholder at Athol Street, Liverpool, where Panacide was given its first large-scale trial. The holder had been a persistent hydrogen sulphide generator for some years, but is now greatly improved.

What can be done to reduce the effects of contamination with sulphate-reducing bacteria? Avoid introducing sulphur compounds into the holder. Water used for filling should have as low a sulphate content as possible—20 ppm. should be the maximum. We have already seen that sulphate-reducers need organic matter, therefore use water of low organic content. Town water is best, if not too costly. Frequently, however, stream or river water must be used. These waters, having passed over soil, will probably be contaminated with sulphate-reducing bacteria and so would profit from bactericidal treatment. When refilling old holders, carefully remove all sludge and sediment before refilling, since these can be a source of reinfection.

## Graphitic corrosion familiar

The graphitic corrosion of iron and steel pipes in water-sodden clay strata must be familiar to all gas engineers and water undertakings and it has been long accepted that the prime cause of the trouble is bacterial action. In general, the trouble is due to *D. desulphuricans*, but it is not uncommon for the whole sulphur cycle to be operative in the immediate vicinity of subterranean pipework. It is generally agreed that this form of corrosion is galvanic in character with the bacteria playing a major role in promoting electrolytic action.

Iron and steel are never perfectly homogeneous and the heterogeneous nature of the pipe favours existence of potential differences between dissimilar areas which lead to rusting when an electric current is able to flow. The corrosion of iron proceeds according to the formula:—

$$Fe + 2H_2O \rightleftharpoons Fe(OH)_2 + H_2$$

The hydrogen gathers at the cathodic spots and the ferrous hydroxide at the anodes. As soon as a monolayer of hydrogen has formed it 'polarises' the electrodes and the current ceases to flow. The above reaction is then seen to be reversible and, thus, will soon reach a state of dynamic equilibrium. The twofold role of the bacteria is to enable the reaction to proceed from left to right to completion, first, by removing the nascent hydrogen and secondly by causing ferrous sulphide to be formed from the ferrous hydroxide.

Where the conditions are essentially anaerobic, steel pipes show corrosion pits, whereas the cast iron pipes are usually 'graphitised'; the surrounding soil is often blackened and will show a high concentration of sulphides. Where the soil is sufficiently particulate to permit ingress of oxygen, the possibility of the complete sulphur cycle operating is introduced and many investigators have reported cases of corrosion where sulphides were present at the lower levels while the soil nearest the surface was found to have a *p*H value about 1.5 to 2.0 due to the action of sulphur oxidising bacteria.

## Several modes of treatment

Several modes of treatment are possible where this form of corrosion is anticipated:—

1. Infilling with non-aggressive soils may be of value; gravel soils are favoured because they induce aerobic conditions.
2. The application of an electric potential has been shown to be of some help.
3. Sacrificial anodes such as magnesium are often used.
4. The application of bactericides is the newest method of treatment which shows promise and is based on sound principles.
5. Soils with an appreciable chromate content are known to discourage sulphate-reducing bacteria.

The oxides used in purifier boxes usually contain viable sulphate-reducing bacteria; add to this the fact that they have a high sulphate content and are continually being enriched with sulphides, and it is not surprising that they should generate $H_2S$. What is more surprising is that we do not hear of more cases of troublesome purifiers than we do. The bacteria responsible for this nuisance are thermophilic and are in no way embarrassed by the relatively high temperatures of their environment.

Concrete sewers are prone to severe corrosion which can result in the complete collapse of the structure. This form of corrosion can be shown to be due to the action of the bacteria of the sulphur cycle with the sedimentary layers acting as a hydrogen sulphide generator, for sulphur oxidisers at the aerated levels to form sulphuric acid. The detailed mechanism is somewhat complex, but can easily be deduced from what has been shown in the earlier sections of this article.

The terms of reference of this article have restricted the contents of the bacteria associated with sulphur compounds. Other micro-organisms giving trouble in the gas industry have been found, but much more space would be required to deal with them: algae which form on cooling racks and static waters, slime-forming organisms in calorimeters, iron bacteria in condenser pipes and occasionally causing 'rusting' of holder lifts and *Sphaerotilus natans* growths at effluent discharge pipes.

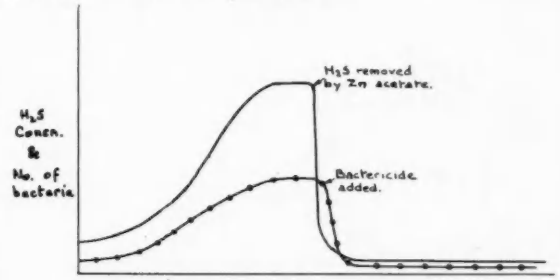



*Fig. 3.—The permanent reduction in the number of bacteria and its effect on hydrogen sulphide concentration by adding a bactericide.*

*From a paper to the South Western Section of the I.G.E.*

# Diesel engines in the gas industry

**By A. J. INGRAM,**

LATELY AREA DIESEL ENGINEER, S.W.G.B.
NOW OF BLACKSTONE & CO. LTD.

THE diesel engine as an industrial prime mover is now well established in the gas industry. Most applications such as its use for driving generators, conveyors, cranes, and shunters, etc., are the same as in many other large industrial undertakings, but its adoption for driving gas compressors and boosters working under varying load conditions is peculiar only to the gas industry. Their reliability, availability and independance of an outside source of power have made them an attractive proposition for these somewhat arduous duties.

The first engine built in the British Empire, using Dr. Diesel's patents, was constructed by Mirrlees, Bickerton & Day Ltd., in 1897. This single cylinder engine with a bore of 300 mm. and a stroke of 460 mm., developed 20 b.h.p. at 200 r.p.m. The diesel engine has developed over the years, until, today, we find engines running at over 4,000 r.p.m. and developing 43 b.h.p. with a capacity of only 1.6 litres. This compares with the 60 b.h.p. of a petrol engine of the same capacity and engine speed. In 1958 over 92,000 diesel engines of different sizes, valued at over £40 mill. were built in the British Isles alone, two thirds of which were exported. Produced by over 40 manufacturers, they are made up of 2,893 different types and sizes.

Diesel engines have many applications in the marine transport and industrial fields, and are now built in all sizes and types to suit the various operating conditions required. For convenience, they are usually classified into three main speed ranges as shown in table 1.

TABLE 1.

| Engine speed, r.p.m. | Classification | Main applications |
|---|---|---|
| Up to 350 .. .. | Low speed | Marine propulsion and pumping. |
| 350 to 1,000 .. .. | Medium speed | Industrial prime movers, generators, and marine. |
| Over 1,000 .. .. | High speed | Road and rail traction and electricity generators. |

Today, the vertical engine is the most popular although many horizontal engines are still built, especially for conditions of low headroom where ideal overhauling facilities are absent, and are popular for long periods on continuous running with very little attention. Many horizontal engines are fitted to road vehicles, but these are often a development of the vertical engine, which has been modified to run on its side. The vertical type of construction has the advantage of requiring comparatively little floor space, and full use can be made of lifting tackle for removing heads and pistons, etc.

A further development of the vertical engine is the V-form and twin-bank types. With the V-form, the cylinders are set at an angle, and one crankshaft only is required, whereas two crankshafts are required for the twin-bank. As the name implies this is basically two engines bolted together with the two crankshafts geared to a single output shaft. This is particularly useful, since the crankshaft speeds may be say 750 r.p.m. while the power output shaft may turn at higher speeds, say 1,000 or 1,200 r.p.m. when driving alternators, and at lower speeds, say 480 r.p.m. when driving compressors. Another advantage is that one bank may be disconnected if the engine is required to run for long periods with less than half load, as may be the case in many compressor installations. Either bank can be disconnected in the Lister-Blackstone engine in about one hour.

There are 25 diesel engines over 100 b.h.p. installed in the South Western Gas Board's area, undertaking a number of duties including driving compressors, d.c. generators, alternators, boosters, etc., but except for a few road vehicles there are no two-stroke engines.

When selecting a diesel engine, reliability, capital and operating costs of the various engines offered must be considered since they are related to the selection of the right engine for a particular duty. Points of primary importance are (a) the engine load, (b) the rating, (c) the speed and size, (d) the engine mounting.

## Ideal loading for engines

An accurate assessment of load conditions must be made, since any engine that is constantly overloaded will give a very poor performance and maintenance costs will be high. It is equally important to avoid long periods of running at quarter load and less, since efficiency will be low with high fuel and lubricating oil consumptions. The ideal choice is for an engine that will be running at about three-quarter load under normal conditions, and so will allow for possible additional loads.

Where extreme load fluctuations are expected, the installation of two small sets rather than one large is worth considering. One set can then be shut down during light load periods and the other still run efficiently. This is particularly so in the gas industry where there are reasonable load conditions during the day but only very light loads at night. In many instances three small diesel compressors of say 100,000-cu.ft. per hour output would be more flexible with lower running costs than say two 200,000-cu.ft. per hour machines.

There may be an initial saving by choosing a high speed engine with reduction gear drive, but for base load conditions a more expensive direct-coupled slow-speed machine may be preferred in order to get longer running periods between overhauls. The capital cost of an engine

in the 450-b.h.p. range can vary by as much as £3,000 depending on the speed.

Whatever the engine rating, power consumed by additional equipment such as gearboxes, air compressors, radiator fans and pumps, etc., must be allowed for. Oil and water pumps integral with the engine will already have been allowed for in the engine rating if the engine has been built to B.S.S. No. 649:1958.

If an engine is required to drive an existing alternator the engine speed will be fixed. It must be remembered, however, that if the speed of a given engine is reduced to suit the alternator, its power will also be proportionately reduced, so that care is needed in choosing the right prime mover to make sure no overload conditions may occur. Full particulars of the alternator should be sent to the engine builders, who will not only supply an engine of the required power and speed, but an engine free of criticals at that speed.

**Space and foundations**

Once an engine has been chosen for a given duty and its size known, the available space for installation must be checked. For ease of maintenance all parts must be readily accessible so that plenty of room must be left on all sides. Finally foundation arrangements must be agreed. It is now usual to mount engines and generators on a common prefabricated underbase, which only requires simple concrete foundations. Engine vibration can be isolated completely from the foundations and surrounding buildings by supporting the combined set on vibro-insulators.

A large common baseplate is generally impracticable for diesel-driven compressors. The compressor is often situated in a flame proof room and is driven by an extension shaft through a flameproof wall gland. Heavy concrete foundations are, however, still needed.

Although water cooled engines have been the most common in the past, air cooling is rapidly gaining popularity. Air cooled engines are now built in this country with powers up to 400 b.h.p. In the gas industry they have many uses, especially on conveyors and stackers, etc. At the Coxside works coal yard there are three stackers and conveyors fitted with twin cylinder 10-h.p. air-cooled engines working in conjunction with two similar electrically driven units. The diesel driven conveyors have had more work since they are moved around the works for coke and oxide handling when required; they are not dependent on an outside source of electricity, which limits the use of the electrically driven sets. They have also proved to be much safer, since they avoid the use of long trailing cables, which are liable to be cut.

These diesel engines have given, and are still giving excellent service, with a minimum of attention. During their six years of running, maintenance has consisted of valve regrinds, cleaning injection equipment and filters, and changing lubricating oil at regular intervals. One engine was recently completely stripped for a major overhaul. The total cost for labour, reboring the cylinders, the supply of oversize pistons and rings, new bearing shells and joints, etc., came to under £30. This overhaul was carried out by one of the Board's own fitters, who until a few years ago had had no experience with internal combustion engines. This was the first complete overhaul he had carried out on his own.

With a regular maintenance routine, these engines have always started easily by hand even on the coldest mornings. They have worked eight-hour shifts day after day in the open in all weathers, and in dusty conditions, with only checks made of the sump oil and topping up with fuel.

In the Devon and Cornwall areas, several small works have been shut down, but small boosters have had to be left at the holder stations for peak gas send-out periods. In many cases these boosters have been converted to diesel drive. Several have radiator cooled engines, but others are air cooled. The air cooled engines are the ideal, since no anti-freeze precautions are necessary during the winter, but lubricating oil heaters may have to be fitted for easy starting in cold weather.

In a recent enquiry for a 30-h.p. engine, it was found that the cost of an air cooled engine was about £40 cheaper than a basic water cooled engine; together with the cost of the radiator and fan, the total saving by installing the air cooled machine was about £80.

If an air cooled engine is to work under cover, it should be installed in a well ventilated building, or if this is not possible, air trunking should be fitted to make sure that a plentiful supply of fresh air can be circulated over the cylinder fins.

The circulating water system of an internal combustion engine is one of the most important services associated with it, and the best method to be used should be given very careful consideration, if efficient and trouble-free running is to be achieved.

Tank cooling using the thermo-syphon or assisted thermo-system is usually confined to smaller engines. The disadvantages are that the tank is cooled only by radiation and convection and, therefore, several tanks may be required. For such installations the air cooled engine has much to offer since the usual winter anti-freeze arrangements can be forgotten.

Until recently, most of the Board's engines used for driving compressors and generators have been equipped with closed circuit cooling, which is the usual method for cooling medium and large installations. Two water cooling systems are used, which are normally referred to as the *fresh* and *raw* water circuits. The fresh or soft water is circulated around the engine and heat exchanger by a pump, usually mounted on the engine itself. A header tank incorporated above the engine with connections to the circulating pump and the highest point in the pipework allows any air in the system to be expelled; it also acts as a make-up tank.

The hot fresh water passes around the outside of the tubes of the heat exchanger, where it is cooled by the raw water passing through the centre. This may be circulated by a second pump mounted on the engine, or be supplied from an independent source. On most compressor installations a pump is specified with an output large enough to supply the cooling water requirements of the compressor and gearbox lubricating oil cooler. The raw water has generally been drawn from a cooling tower pond, which is also used for other gasworks services, and is returned to the tower for cooling. The water in the pond is checked at intervals by the laboratory and chemically treated as required.

**Cooling by radiator**

The last method of engine cooling, which is rapidly gaining popularity for stationary engines, is the radiator. It has the advantages of a closed circuit, and dispenses with the raw water system. The radiator is divided into two parts with one section for water, and a smaller section for lubricating oil cooling. A fan is necessary, which can be driven directly by the engine or by an independent motor depending on general layout. If the fan is driven directly by the engine, allowance must be made for the power required and engine output derated accordingly. This is particularly important with small engines, but in larger installations power is usually in excess of requirements, and derating may not be necessary.

The cost of a radiator is high initially, but a proportion

of the capital is recovered by the saving in pipework, raw water pumps, pipefitters' time, and possibly a cooling tower. With diesel driven water cooled compressors, also requiring water for gearbox oil cooling, the use of a radiator for the engine only may not be justified, but it may be worth considering installing a larger unit, capable of handling the extra cooling water required for gearbox and compressor.

The modern diesel engine is one of the most efficient prime movers known. Small engines with indirect injection may have a thermal efficiency in the order of 28%, compared with figures of 36 to 37% for larger engines. These figures compare with thermal efficiencies of about 30% in modern power stations and 17 to 18% for gas turbines. Even with efficiencies of 36%, nearly two thirds of the heat value is lost. This is made up approximately as follows: (expressed as percentages).

Doing useful work: 36.
Lost in jacket water cooling: 24—recoverable.
Lost in exhaust: 30—50% recoverable.
Radiation and other losses: 10.
Total heat value of fuel: 100.

Much of this heat can be recovered in the form of hot water or steam, the amount depending on the load factor of the engine, the temperature of water or the pressure of steam required, etc. Nearly all the 24% of the heat lost through the jacket water and about half that of the exhaust can be recovered, bringing the overall thermal efficiency up to 75%. A diesel generator with electrical output of 360 kW., if fitted with waste heat recovery would, therefore, produce the equivalent of a further 390 kW.

No gasworks in the South Western area has yet made use of heat recovery, but many mills, where large quantities of hot water and low pressure steam are needed, have reported net thermal efficiencies of up to 88% with waste heat recovery.

With engines driving compressors running under variable load conditions, waste heat recovery would not be worth considering, but with diesel generators running on a good load factor, considerable savings can be made. Under ¾ load conditions, 1 lb. of steam at 30 p.s.i. can be produced per kW of load, or under full load just over 1½ lb. at the same pressure per kW load.

Full waste heat recovery equipment may cost between £1,000 and £1,500, depending on the degree of automatic control required, so that careful thought is needed before any scheme is put into practice. If hot water is required for central heating, shower baths, etc., greater savings can be effected than if steam at 100 p.s.i. is produced.

One cheap method of partial heat recovery in many works could be achieved by using the exhaust for heating boiler feed water. No automatic valves would be required in such a system, since the boiler feed temperature would vary with the engine load. With the generator previously mentioned, a thermal efficiency of over 50% could be attained.

**Higher maximum pressures**

Many engine buyers are rather nervous when it is suggested that they buy a pressure charged engine. They are usually of the opinion that the manufacturer has found a dodge to get extra power out of a given cylinder size. This is far from the truth, since most diesel engines have been designed for pressure charging, and the extra strength is built into the engine to take the higher maximum pressures.

The maximum power a given engine can develop depends upon the amount of air drawn into the cylinder on the suction stroke. This varies with the atmospheric pressure, and also accounts for engines being derated at high altitudes where the air is less dense.

In order to increase the power from a given cylinder size, pressure or super charging is adopted, which boosts air into the cylinder at about 5 p.s.i. This figure varies with different manufacturers, depending on the design. The extra air in the cylinder enables more fuel to be burnt and so increases the power. Usually an increase in power of 50% is obtained, but some manufacturers by fitting air intercoolers also have almost doubled the power of a normally aspirated engine.

There are two main methods of pressure charging. One is by fitting a turbo-charger and the other by a mechanical blower. Turbo-charged blowers are preferred for four-stroke engines and mechanical blowers are usually fitted to two-stroke engines. Since there are no medium size two-stroke engines in the South Western area, turbo chargers only will be described.

**Advantage of turbo blower**

The main advantage of the turbo blower is that it virtually requires no power to drive it. The power is derived from the heat energy of the exhaust gases, which are wasted in a naturally aspirated engine. As the output of the pressure charger varies with the load on the engine, a load increase causes an increase in blower speed, thus giving a higher boost pressure. Better scavenging of engine cylinders takes place, as the openings of the air and exhaust valves are timed to overlap, so that fresh air is swept through the cylinder, removing all traces of burnt gases. This burst of air also cools the combustion spaces and valves and so increases valve life. With turbo charging, the mechanical efficiency is higher than a naturally aspirated engine since there are virtually no extra friction losses. The turbo booster also acts as a silencer on an engine, and can often save the cost of extra silencing equipment.

For high altitude working, the percentage derating is considerably less, if at all, when a suitably designed blower assembly is fitted. The turbo charger requires little maintenance. Bearings should be renewed as recommended by the manufacturers, and oil levels and water cooling spaces checked regularly. If the engine has been laid up, the drain plugs should be removed from the bottom of the casing to drain off any condensate that may have collected.

The principal advantages of turbo charged engines compared with naturally aspirated engines are (a) slightly cheaper in capital cost, per b.h.p., (b) smaller overall dimensions and less weight, thus effecting a saving in foundation costs, (c) lower fuel and lubricating oil consumption, per b.h.p. and (d) a smaller quantity of cooling water required, hence a saving in cost of cooling equipment, per b.h.p.

The cause of many oil engine stoppages can be traced to the use of wrong or dirty fuels. Users should strictly adhere to one of the grades recommended by the engine makers, a list of which is always included in the instruction book supplied with the engine. If any of the grades mentioned are not available your normal oil supplier will be only too pleased to give advice.

Fuel oils are divided up into three main quality grades; class A which is more commonly known as gas oil, is a superior grade to class B, which is sometimes referred to as diesel oil. Both these grades are covered by the B.S.S. No. 2869:1957. The third grade covers a large range of residual fuels which are often referred to as boiler oils. This latter range of fuels should never be used unless the engine has been designed and equipped with suitable clarifying and heating equipment. Derv (Diesel Engined Road Vehicle) is a gas oil for the use of road transport vehicles and, therefore, is subject to tax.

Most of the large works in the South Western Gas Board area have carburetted water gas plants which require large quantities of gas oil so that the bulk storage of fuel has

not presented any difficulties. Traces of water present which have not caused trouble in the c.w.g. plants could, however, cause stoppage of any diesel machinery. Main storage tanks should, therefore, be checked and any water that has settled out, drained at regular intervals.

The 'ignition quality' of a fuel controls combustion shock and, therefore, smooth and quiet running. It is also responsible for ease of starting in cold weather. The most satisfactory method of determining the ignition value—known as the 'cetan number'—of a fuel is by the use of a test engine.

The 'cetane number' of a fuel is the percentage by volume of cetane in a mixture with alpha-methyl-naphthalene, which is equivalent in ignition quality to the fuel being tested. Cetane, itself a hydrocarbon, has a high, whereas alpha-methyl-naphthalene has a very low ignition quality. The delay between the start of injection of fuel into a combustion chamber and the time combustion actually commences is known as the 'delay period'. It is to determine 'ignition delay' that the cetane test is carried out, since some engines are more sensitive than others. This applies particularly to high speed engines.

Viscosity is important since it affects the flow of fuel through pipes, filters, injection equipment and its atomisation in the cylinder or its combustion.

In the British Isles the Redwood system of rating is the usual standard of measurement. Viscosity is also an indication of the grade of fuel since it increases as the quality of fuels deteriorate. Where high viscosity fuels are used, such as those above 200 seconds Redwood No. 1 at 70°F, some form of fuel heating is normally required, depending on the ambient temperature.

In the Conradson carbon residue test, a sample of fuel is heated under closely specified conditions until an ultimate residue of coke is obtained. It is, therefore, a check of the high boiling point material in a given fuel and gives some indication of the ability of the fuel to form carbon deposits. With residual fuels the Conradson carbon content is much higher than with pure distillate fuels, and is one reason why there is more wear in an engine using these grades. Medium viscosity heavy fuels such as the 950 seconds grade are a blend of residual and distillate grades, and therefore the Conradson figure depends on the proportion of residual fuel.

The value of the flashpoint test is to determine whether a fuel contains any volatile matter which would make it dangerous to store. In general it is usual to specify that the closed flashpoint should not be below 150°F.

The variation of fuel oil calorific values is much less than with different coals, since most petroleum fuels have gross calorific values between 18,500 and 19,500 B.t.u. per lb. The net calorific values are about 1,200 B.t.u. per lb. less.

### Importance of checking water

A careful check of water content must be kept since engine users pay the same rate, as for the fuel on a weight basis. If the fuel storage tanks are properly installed with drain cocks, and the water allowed to settle out and drained away, it will cause no trouble. The ash content of the fuel can usually be ignored in high grade fuels, but in residual fuels it must be reduced to a reasonable level by the use of centrifuges. The ash is composed of silica, iron oxide, vanadium oxide, and other abrasive matter which can cause heavy wear of cylinder liners, injection equipment and valves, if not reduced.

The Newham works at Truro is dependent on two Mirrlees K3 285-kW diesel alternators for its supply of electricity and with an average works load of just over 200 kW one is normally standby to the other. These engines are both designed to run on residual fuels, and are fitted with chromium-plated liners for this purpose. Up to the present a 950-seconds grade of fuel has been used with gas oil for starting and stopping only.

Both engines have run for over 14,000 hours and have been trouble free. A comparatively short period such as this is not long enough to assess the economics of using heavy fuels, but so far running costs have been low with electricity produced at a figure much lower than if a supply was taken from the grid. The engines have been run for four-week periods which has proved to be a satisfactory running time. At the end of each period all cage type exhaust valves and fuel injectors have been changed and overhauled.

Major overhauls, which included lifting pistons, renewing rings, checking bearings, etc., have been carried out after 5,000-hour running times. Air inlet valves, which are not of the cage type, were not ground-in until the first major overhaul, but experience has proved that these valves lasted better if reground at 2,500-hour intervals.

### Average cylinder wear

At 5,000 hours the average maximum cylinder wear found in one engine was .003 in. and the other .005 to .007 in. At 10,000 hours two cylinders of the first engine were found to have worn to .020 in. and the third cylinder .0085 in. The two bad liners were replaced by reconditioned ones, since the original chromium thickness averaged between .024 in. and .027 in. Liners in the second engine were still good with a maximum wear of .009 in

New piston rings and injector nozzles were fitted during each major overhaul and fuel pump barrels and plungers renewed at 10,000 hours. All bearings were found to be in good order except one large end bearing which was renewed at 10,000 hours.

With the present price of fuel oils, over £1,300 per annum has been saved on fuel bills at Newham. This is not all profit as the capital cost of the engines and ancillary equipment was much higher than if they were to be run on gas oil. Extra tanks, heaters and centrifuging equipment had to be installed to purify the oil. These items came to over £2,500.

Since it is vital that the time taken for major overhauls is kept to a minimum, the makers have always supplied an engineer to take charge. Normal repairs have always been carried out by the Board's own staff.

When an engine is run on residual fuel, maintenance costs are always higher than for engines run on light fuels. General wear is always greater and more spares required. The average cost of each major overhaul including Gas Board labour and replacement parts and sump lubricating oil change has been £210. When the two liners were replaced the overall cost came to £481 with replacements costing £309.

The overall generating costs have been under 1.4d. per unit, of which the annual capital depreciation and interest charges and fuel cost totalled 1.087d. per unit. The case for waste heat recovery at Truro is worth considering, and this is being given careful thought.

B.S.S. No. 3109:1959, defines a dual fuel engine as a compression ignition engine which operates either on liquid fuel only, or on gas with injection of liquid fuel, the change from dual fuel being possible while the engine is running.

An engine that can use either gaseous or liquid fuels can be a valuable asset for the production of cheap power in many industries, especially where intermittent sources of fuel gases are available, or where gas boards have attractive off-peak tariffs.

Some area gas boards have contracts with coke oven

# DENSO MASTIC H.D.

## PLUGS . . . SEALS . . . PROTECTS . . .

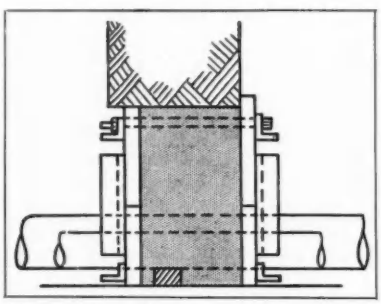
*Building up a pipe joint with Mastic H.D. before wrapping with Denso Tape*

DENSO MASTIC H.D., meeting the requirements of the several B.S. codes of practice, is one of the most useful products offered to Industry. If there is a hole to be plugged, Mastic H.D. will plug it . . . If there is an aperture to be sealed, Mastic H.D. seals it . . .

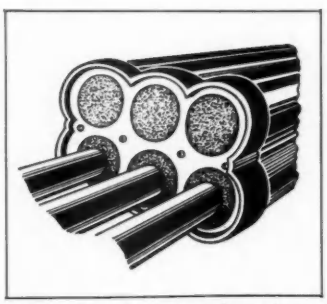
Mastic H.D. stops rust, prevents corrosion—above or below ground . . . or under water.

Easily cold-applied, it forms a perfect seal, impervious alike to air, gas and water. [Permanently plastic, with infinite shelf life, it is always ready for instant use.

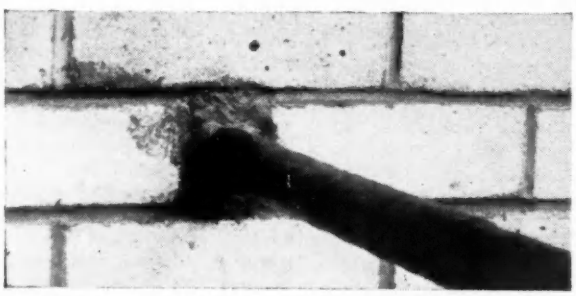
*Shows joint half wrapped*



*Mastic H.D. makes a water-tight compression joint for cable duct sealing*



*Mastic H.D. effectively seals pre-formed cable and pipe ducts and plugs spare ways*



*Mastic H.D. seals walls breached to allow pipe service entry*

DENSO ANTI-CORROSION PRODUCTS

## WINN & COALES LTD

| LONDON | MANCHESTER *(Also Contracting Dept.)* | BELFAST | DUBLIN |
|---|---|---|---|
| Tel: GIPsy Hill 7511 | Tel: Sale 8271 | Tel: 56623 | Tel: 61768 |

**Agents throughout the Commonwealth**

works and oil refineries to take all the surplus gas from these plants, and at certain periods of low gas send-out there may be an excess of these gases. During these periods a dual fuel engine can be run on the surplus gas to produce relatively cheap power.

In the early 1920's, experiments were carried out with one of the diesel engines for the airship R.101 to enable it to burn hydrogen. As the fuel oil was used up by the engines, gas had to be released from the gas bags to maintain altitude. It was therefore hoped to increase the range of the airship by utilising this otherwise wasted gas. Reports say that although the experiments were successful, the system was not adopted.

The greatest boost for the development of the dual fuel engine in this country probably came from the introduction of the activated sludge system of sewage treatment. Considerable power is required by the blowers used for oxidising the sludge, and large quantities of gas with a high methane content are produced. This is an ideal fuel for dual fuel working to produce the power required.

In the early days low compression gas engines were used until the National Gas and Oil Engine Company in 1939 converted an engine to run as a dual fuel engine. The system was successful, and today we have several manufacturers building this type of prime mover, which is basically a diesel engine. The old type of gas engine had a low compression ratio of about 5:1 compared with about 15:1, depending on make, of the modern diesel or dual fuel engine. Pre-ignition does not take place when the gas air mixture is compressed as it contains an excess of air. Provided the ratio is above a certain minimum value, the hot mixture will ignite when pilot fuel oil is injected for this purpose. The quantity of oil required is in the order of 7 to 10% of normal requirements, but may be more if a low calorific value gas is used and engine power still maintained.

One well known manufacturer recommends that the lubricating oil used in their engine should be changed at 1,200 hours running time. They do, however, point out this figure may be varied to suit site conditions. In some stations with good conditions this figure has been improved, but at other works the oils have had to be changed more often.

With standby diesel compressors running for only a few hours a week, it may take several years to reach 1,200 hours running time, and in such cases a sample of oil should be sent to the oil supplier to be analysed for fuel oil, sediment and possible moisture content, at regular intervals.

## Detecting fuel leaks

If an engine has totally enclosed fuel injection equipment, a very slight fuel leak may not become apparent, whereas a bad leak would cause the dipstick level to rise and so give a warning that all was not in order. With the engine running, the first indication of a bad fuel leak may not be noticed until the exhaust temperature of a particular cylinder falls. It may be argued that the attendant would hear the uneven beat of the engine, but in most cases the engines are only inspected hourly, and then often by unskilled labour.

Straight mineral oils are the simplest oils on the market and can be used in many diesel engines. These oils deteriorate more quickly at high temperatures than detergent oils, and have no special properties to prevent sludging in the crankcase. As the oil is relatively cheap many users still use these grades, but oil changes must be made more frequently.

In an engine crankcase with the constant churning up of the oil as it is being circulated, frothing takes place, and it is in this condition that the oil mixes with any gases present, forming organic acids. Additives are introduced into detergent oils to keep this condition to a minimum.

Other additives are used with detergent oils to reduce oxidation. On hot cylinder liners gummy and carbonaceous deposits are formed from the excess of air from combustion, thus causing decomposition of the lubricating oil, forming gums and lacquers. This, in turn, prevents the rings from working freely in the piston grooves, causing blowpass and loss of power.

As fuel oils contain a certain amount of sulphur, depending on the grade, corrosive acids are formed during combustion. With good load conditions and high exhaust temperatures there should be little condensation of acid. Unfortunately, with diesel driven compressors running at times at minimum speed and low output pressures, exhaust temperatures are low and more liable to this contamination, which is the main cause of cylinder wear. With suitable jacket water temperature regulators to keep the jacket water temperature outlet above 160°F., which is well above the dew point, this danger can be kept to a minimum. Anti-acid additives are contained in detergent oils to help the oil to combat acid decomposition and reduce wear of rings and liners.

## Diesel prime movers

In the area covered by the South Western Gas Board, nine large compressors are installed with diesel prime movers. Of these, the Belliss and Morcom set at Bath has been run for long periods and three of the Blackstone driven sets, installed as standby to electrically-driven compressors have run for between 8,000 and 11,000 hours each. The remaining three Blackstone and two Allen driven compressors have been used for standby only, and have run for periods totalling less than 1,200 hours each.

Up to January 2, 1960, the Belliss and Morcom compressor had run for 22,528 hours out of maximum possible of 26,616 since first put to work in December, 1956. This engine has run for long periods at a time, and has rarely had to be shut down for adjustment or repairs between normal overhauls. I think this is a very good example of the reliability of the modern diesel engine.

The maintenance schedule as recommended by the manufacturers, for the Bath diesel compressor has been adhered to. The 4,000-hour major overhauls, when cylinder and pistons are lifted, have been carried out during the autumn and spring, and injectors removed for overhaul every 2,000 hours. The sump lubricating oil has been analysed at regular intervals and up to January 2, 1960, had been drained and renewed only six times.

Recently, the Gas Board's own fitters have carried out all overhauls, and have been able to shut the engine down on Monday mornings and have it back at work again by the following Friday evening.

It has been found worth while carrying a ' service ' cylinder head where Blackstone engines have had regular use. When the 1,200-hour top overhaul at the Coxside works is due it has been the practice to use the compressor set during peak compressing hours, and then shut it down at 2.00 p.m. One fitter and a mate, have found it an easy task to replace a cylinder head by a reconditioned one, and have the engine back at work before 5.00 p.m. The worn cylinder head is then overhauled at a convenient time without the engine being out of action. A similar method has been adopted at other works, depending on availability of other compressors. When pistons are due for inspection a similar system has been used when the engine has been left ready for use each evening.

During each major overhaul, cylinder liner wear readings have been taken. Big end pins have been checked for

ovality and at the end of the overhaul crankshaft deflections measured. Main bearings have also been inspected if deflection readings have indicated the need. In some instances I would like to have seen them examined more often.

Apart from one cylinder, maximum wear of .008 in. was the average wear for all cylinders of the Belliss and Morcom diesel after 16,876 hours running time, giving a figure of .0005 in. per 1,000 hours. Under normal conditions wear for this size of cylinder can be permitted up to a maximum of .050 in., so that these liners have still a long life. The main objection to using worn liners is the possibility of heavy lubricating oil consumption. Piston ring grooves also wear excessively with the rings moving in and out of the grooves as the piston works up and down an uneven liner.

Crankcase explosions have been relatively rare because the engines have been well designed and built to high standards of construction. Of the explosions recorded, the causes have been found almost invariably to be due to overheating followed by ignition of the lubricating oil mist and the air present in the crankcase. At the first indication of overheating an engine should be slowed down, or stopped as circumstances permit. Crankcase doors should not be removed until the engine has had a chance to cool down. When the doors have been removed do not spray the hot bearing with oil as this may produce an inflamable vapour, and increase the fire risk. Naked lights must not be used or allowed in the vicinity of the engine.

Many engines are now fitted with precision steel backed white metal or copper lead bearings. These are fitted, and the engine run for half an hour at low revolutions. A check should then be made by hand, and if a hot bearing is found it should be stripped and examined, and if faulty, replaced. If the bearings have been fitted according to instructions, and no extraneous matter allowed to remain on the bearing shells or pins, they should give long and trouble-free service, free from overheating.

Crankcase explosions have usually been associated with internal combustion engines but they have occurred in steam engines due also to hot bearings. Industrial diesel engines are normally supplied without crankcase explosion doors, but they can always be supplied as an extra item if required.

If an engine is required to work in a possibly dangerous area, I recommend that they be fitted, but the main objections to them is that they are usually a source of oil leaks, and if they are not checked the engine finally gets arrayed with an assortment of tin cans.

Breakdowns are costly and always seem to occur at the most inconvenient times. The best insurance is to maintain a rigid maintenance schedule. Maintenance staffs in the area, although trained on steam plant in most gas works have adapted themselves extremely well to the running and maintenance of these comparatively new comers to the gas industry. I would, however, recommend that fitters be sent to engine manufacturers' works for short courses. The small cost involved will be more than amply repaid by the time saved during overhauls. Finally I suggest that diesel plant should be standardised where possible. Large horse power ranges can now be covered by similar engines with varying number of cylinders and with pressure charging. This in turn will keep the amount of spares in stock to a minimum and save capital.

# Natural gas powers U.S. air conditioning system

INSTALLED to demonstrate natural gas as a driving power for an air conditioning system, but claimed to operate at a cost comparable to that of any other energy source, an interesting installation has recently been put into operation by the Milwaukee Gas Light Company, of Milwaukee, Wisconsin, U.S.A., to serve the display areas of the company's main office building.

Apart from the desire to use gas to the fullest possible extent, investigations revealed that the installation of a compressor with a natural gas engine would be no dearer than that of an electrically-driven compressor, and since existing electric facilities were inadequate for handling the compressor load, the cost of additional wiring and other sub-station equipment would have been much higher than that for installing the necessary gas service piping.

No chimney was available, thereby eliminating the possible use of any other type of heat-driven equipment. At the same time, operational advantages with the use of the equipment selected could be achieved through complete modulation of capacity, and the refrigeration machinery could be varied in speed by automatically varying the speed of the prime mover.

The chilled water plant installed was made up of standard components selected and assembled to form a complete operating unit. The basic components consisted of a Waukesha gas engine model 145 CZB with manual clutch; a Young radiator using cooling tower water, a plug valve installed in the circuit regulating the flow of water to the radiator, thus controlling engine temperature, and a Fisher diaphragm valve being used as a throttle control; a Terry steam turbine type O high speed increaser to increase the engine speed to drive the compressor; and a Carrier 17-M-32 centrifugal compressor, with necessary condenser and cooler. The condenser water pump, also driven by the engine, is an Aurora type GGU size 3BX4, rated at 500 g.p.m. with a 45 foot head. Control is by means of a Johnson Service Pneumatic system operating on the return water temperature, and capacity control is accomplished first by reducing the speed of the engine approximately 1,800 r.p.m. to 1,400 r.p.m., then by operating the suction damper on the Carrier compressor.

This installation is, in fact, part of an overall air conditioning system which will also include an absorption unit located on the 19th floor of the company's building. The instrumentation of both systems is being installed so that all the data may be collected from a central operating panel. This equipment is in the process of being installed.

After the air leaves the cooling system it flows into the space above the ceiling and then finds its way through thousands of ceiling pores, spreading the air flow over the entire area and eliminating draughts. A slightly different arrangement applies in the lower sales level and the first floor. At the latter level, for instance, a slightly different form of perforated ceiling is used to perform the same functions of acoustic treatment and air distribution.

On both floors, however, there are airtight partitions above the ceilings dividing them into several separate areas, each of which has its own air supply duct and reheat coil. This makes possible the control of each air conditioned space by separate thermostats, so that the side of the building receiving the most sun, or accommodating the most people, can be controlled differently from the opposite side, depending on the weather.

Out of the way, by the elevators, are the few grilles which return air into the ductwork for conveying back to the air conditioning system in the basement.

# Commons will keep a closer watch on public spending

## WHITE PAPER ON STATE INDUSTRIES WILL BE DEBATED EVERY AUTUMN

INCREASED opportunities for Members of the House of Commons to examine and criticise public expenditure were announced last week by Mr. R. A. Butler, Leader of the House. The proposals, which received a general welcome from the House, will be discussed in detail when Parliament resumes on October 25 after the summer recess.

Under the new arrangements there will be: The enlargement of the Select Committee on Estimates from 36 to 43 backbenchers; the appointment of a new subcommittee to report upon the Spring supplementary estimates early in the year; a special report on the main differences between each year's estimates and the last; three extra days, one apiece out of Government, Opposition and private members' time, on which the House will debate reports from the Estimates Committee and the Public Accountants Committee.

### Supply days

A White Paper each autumn on the investment programmes in the public sector, including nationalised industries, will be debated before Christmas; and two of the Opposition's 26 allotted 'supply' days will be taken before Christmas.

In addition, Mr. Butler promised to report from time to time conclusions reached by the Government on the advice of a committee under Lord Plowden's chairmanship which is reviewing the methods of controlling public expenditure.

Mr. Butler said these proposals should be put into effect next session.

Mr. H. Wilson (Lab. Huyton) said he was sure that what the Leader of the House had said was on the right lines. While the House could not go into major questions of policy when discussing finance, what they must be concerned with was getting value for money.

### Capital allocations

Mr. G. Nabarro (Con. Kidderminster): 'In dealing with Clause 72 of the Finance Bill, concerning Exchequer advances to nationalised industries, the Chancellor of the Exchequer promised the Committee that a full statement would be made in the autumn about Parliamentary facilities for examining individually the capital allocations, of nationalised industries and voting the

Continued on p. 174

## *MORE PAY FOR GAS STAFFS*

PAY increases ranging from £15 to £129 a year have been negotiated for nearly 35,000 clerical, administrative and professional workers in the gas industry.

The rises will be back-dated to June 1, and will cost about £1.75 mill. a year.

Recent increases in gas prices anticipated the award.

## NEW GAS RADIANT HEATING SYSTEM IS WORLD'S LARGEST

BELIEVED to be the largest gas radiant heating system in the world 480 gas overhead heaters have been installed in the eight bays of the Cammell Laird Company's new ship prefabricating shops at Birkenhead.

The eight bays cover an area of more than 11 acres, and the roof heights vary from around 60 to 80 ft. The lengths of the open-ended bays vary from 750 ft. (five) to 500 ft. (two) and 350 ft. (one).

The problem was that with so vast an area to heat, 'indirect' methods—utilising circulated steam or hot water with pipes and radiators, for example—would have to be brought into operation some considerable time before each day's work started.

This, and the inflexibility of such a method, would tend to increase fuel costs. Therefore, it was decided to use A.M.6 Parkinson Schwank gas radiant heaters, mounted overhead.

The cost of installing this overhead system was estimated to be between one-third and one-half of a boiler system capable of providing similar standards of heating. The running cost, comparatively, is approximately two-thirds.

**NEWS SUPPLEMENT**

## Digest shows fuel availability in United Kingdom

THE 1959 edition of the Ministry of Power Statistical Digest (H.M.S.O., 30s. net) gives comprehensive statistics of the fuel and power industries in the United Kingdom.

An important section deals with the energy position as a whole showing, among other things, the production and availability of primary and secondary fuels and consumption by class of consumer and type of fuel over a number of years.

Separate sections deal with coal, electricity, gas and petroleum in varying detail.

The new edition in the main follows the pattern of recent issues, but some new tables have been added and two or three which were in the 1958 edition have been omitted. A major addition expands the information about imports and exports of crude petroleum and petroleum products, particularly in showing the value of imports by country and origin and exports by country of destination.

A new table gives an overall picture of the supply and disposal of petroleum products in the United Kingdom; a table on these lines was last included in the 1955 issue.

A new table covers persons employed in the gas industry according to the nature of work done, the analysis differing substantially from that given earlier.

## Scottish Board abolishes that standing charge

THE Scottish Gas Board is to abolish the standing quarterly charge, about which there have been many complaints since it was introduced last August.

But as a result of the revised tariffs announced last week, most domestic consumers will pay 1d. a day more. In no case will the increase be greater than 1½d. a day.

The first 26 therms used will be charged at 3s. 1d. a therm, and the next 1,200 at 1s. 10½d. per therm. There will be further reductions for larger amounts.

To benefit non-domestic consumers, the optional two-part tariff has been extended to cover meters of up to 700 cu.ft. an hour capacity. Previously it was limited to meters up to 400 cu.ft. an hour.

# Commons to keep closer watch

from p. 173

sums concerned before the money is spent.'

He asked whether the reference to a White Paper on public expenditure, 'a sort of compendium of all public expenditure,' gave those precise facilities to examine the individual capital allocations of nationalised industries and not, 'in a single comprehensive form on a sort of innocuous Motion to take note of a White Paper, which would be useless to my hon. Friends and myself?'

Mr. Butler said the original suggestion was that the investment programmes of the nationalised industries should be published. To make the scope wider, the Chancellor had since suggested that the publication should be about investment programmes in the public sector, including the nationalised industries. That should give an opportunity to Members to examine those matters in the autumn.

The Chancellor had also told the House that he would publish another White Paper in February or March on the estimated figures of borrowings to meet the programmes of the nationalised industries during the ensuing financial year. In those two respects, therefore, there would be a considerable advance, of which Mr. Butler said, he hoped Conservative members would take full opportunity.

Mr. A. Woodburn (Lab., Clackmannan and E. Stirling): 'Is there any reason why public investment or public advances should be examined only in so far as they are concerned with nationalised industries? Since so much money is now being invested in the other leg of the mixed economy, is it not proper that the whole question of public money advanced for industry, whether nationalised or private, should be examined?'

Mr. Butler: 'That is why my right hon. Friend suggested the enlargement of the White Paper which he has offered to cover investment programmes in the public sector.'

## Investment programmes

IN the House of Commons last week Mr. Gerald Nabarro (C. Kidderminster) asked the Minister of Power, Mr. Richard Wood, having regard to capital investment in the public sector next year being retained at this year's level, what his estimate was of the consequent effect upon the production and productivity of the coal, gas and electricity industries.

Mr. Wood: 'The investment programmes of the nationalised fuel and power industries are being reviewed in the light of the Chancellor's general policy statement about holding total public sector investment in 1961-62 to the level of 1960-61. The review has not yet been completed.'

*Air Products (Great Britain) Ltd. in association with the Butterley Company have completed building an oxygen plant at Stewarts & Lloyds' steelworks, Corby, Northamptonshire. The plant has an output of 200 tons of oxygen per day and is the first to be owned and operated by a steel company in Great Britain. Gaseous oxygen is produced at a pressure of 350 lb. per sq.in. and at 99.5% purity. Gas storage under pressure is provided for 370,000 standard cu.ft. of oxygen. The plant incorporates the latest developments in 'low pressure cycle' oxygen plant design, and provides low power consumption per ton of oxygen. This type of plant is to be recommended where liquid production and storage facilities are not of primary importance.*

## PROJECTED MEXICO—U.S. PIPELINE TO BE ONE OF LONGEST IN WORLD

PETROLEOS Mexicanos (Pemex) and the Tennessee Gas Company plan to build a gas pipeline from Reynosa in Tamaulipas to Mexicali in Baja, California. It will be one of the longest gas-ducts in the world, spanning more than 1,200 miles of Mexican territory and using in its construction 450,000 tons of Mexican steel.

### Mexican property

It will remain, according to Mexican law, entirely the property of Mexico, and will be operated by Pemex.

The director of Pemex, in making the announcement, emphasised however, that the project is only in its preliminary stages.

### Feasibility unconfirmed

Tennessee Gas has certain legal problems to overcome and engineers have still to confirm that the project is feasible.

If it is built, the duct will supply the northern states of Mexico and also some parts of California. Thirty-four-inch tubes will have a capacity of 750 mill. cu.ft. of gas per day, of which about 425 mill. will be sold to the U.S.

## PUTTING IT OVER

The North Western Gas Board is using an aeroplane to circle over towns with a streamer with the words 'Gas Cuts Costs.'

## VALVEMAN DIES

Mr. Spencer Wade, aged 45, valveman, of Alexandra Road, Richmond, Surrey, who, as reported last week, was injured in the explosion at Richmond gasworks on Sunday, died during Monday night.

## PERSONAL NOTES

# Secretary of Eastern Gas Board

MR. F. J. MARTIN has been appointed to succeed MR. R. H. EPPS as Secretary of the Eastern Gas Board with effect from October 1. MR. R. R. HARDWICKE will be the new Assistant Secretary with effect from the same date. Mr. Martin is aged 41 and Mr. Hardwicke 46. Both officers have spent their professional life in the industry, and Mr. Martin has been at the centre of the Board's administration as assistant secretary since nationalisation in 1949. He was educated at Chiswick Grammar School, and joined the British Gas Light Company at its head office in Westminster in 1935. He spent ten years in the accounts department before being transferred to the secretarial side. At the beginning of 1948 he was appointed assistant secretary to the British Gas Light Company and of its 23 subsidiary gas and/or water undertakings, and assistant to the general manager. In addition to his appointment as assistant secretary to the Board on nationalisation he was appointed secretary of the subsidiary, Westgate & Birchington Water Company. Mr. Hardwicke was deputy secretary and accountant of the Board's Watford Division until November last year, when he was seconded to the Board's headquarters for special secretarial duties. Mr. Hardwicke joined the secretarial department of the former Watford and St. Albans Gas Company at the age of 17. During the war years he served in the R.A.F., attaining the rank of squadron-leader, and won the D.F.C. He returned to the former company in 1946 and was appointed its assistant secretary at the beginning of 1947. On nationalisation he became the Watford Division's deputy secretary and later deputy secretary and accountant. Mr. Hardwicke is a Fellow of the Chartered Institute of Secretaries and an Associate Member of the British Institute of Management.

MR. R. BROUGHTON has been appointed Chief of the technical sales department of the Pulsometer Engineering Co. Ltd. incorporating Joseph Evans & Sons (Wolverhampton) Ltd., of Reading and London, designers and manufacturers of pumps and pumping equipment.

MR. H. STREETS has been appointed to the Board of Sutcliffe Plant Hire Ltd., whose offices are in Bond Street, Wakefield. Mr. Streets, who is also a director of Richard Sutcliffe Ltd., is the author of the book *Sutcliffe's Manual of Belt Conveying.*

DR. D. B. MULHOLLAND has been appointed Head of the Department of Chemical Engineering at West Ham College of Technology, and takes up duty in September.

ALDERMAN G. E. HODGKINSON, O.B.E., has been re-appointed a part-time Member of the West Midlands Gas Board.

## *COMPANY NEWS*

### DRAKES LTD.

DRAKES LTD. of Halifax have announced that no large orders for traditional carbonising plant have been placed with them by the gas industry. This information comes from the company's annual report, in which it stated that group profits after tax for the year ending December 31, 1959, are £2,609.

The Chairman's statement says; 'Once again I have to report that there has been no placing of any large orders for new plant by the gas industry for traditional carbonising plant, and as a result, the company has been under-employed throughout the whole of the year under review.

'The placing by them of orders for repairs has been on a smaller scale than previously and more reliance has had to be placed on orders from outside the gas industry.'

The company's A.G.M. is to be held on August 18 in Halifax.


*GAS DISTRIBUTION ENGINEERING*

R. N. LE FEVRE, M.B.E.
*M.Inst.Gas E., A.M.I.Mech.E*

The book deals with the general principles involved in conveying towns gas from the works to comsumers' premises. Invaluable to Students and others desiring a general knowledge of gas distribution.

*Price* **34/-** *inc. postage*

*MANUAL OF GAS FITTING*

R. N. LE FEVRE, M.B.E.
*M.Inst.Gas E., A.M.I.Mech.E.*

Completely covers the theory and practice of Gas Installation Work and the Servicing of Appliances and Equipment — a possession essential for Students, Sales and Service, Distribution and Fittings Personnel.

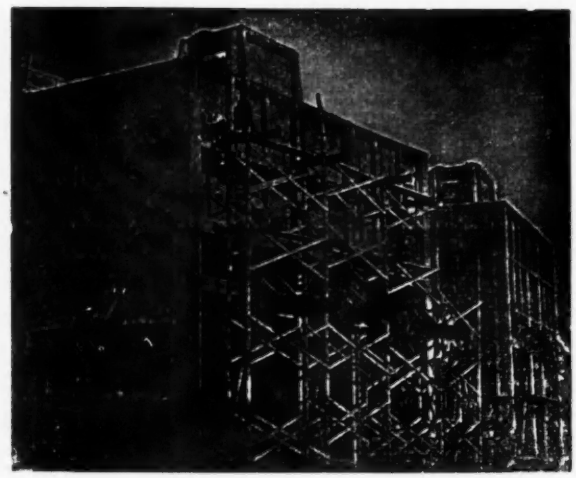
*Crown 8vo - 895 pages*
*666 illustrations*

*Price* **45/-** *inc. postage*

**WALTER KING LIMITED**
**11 BOLT COURT · FLEET STREET · LONDON E.C.4**

3—7/58

# Gunite



*One of the reinforced concrete structures reconditioned with Gunite at the Carlisle Works of the Northern Gas Board*

**Gunite**—concrete applied by air pressure—has numerous applications where its great density and extreme adhesion have exceptional value.

**For repairing reinforced concrete** it has particular me it, as, due to the method of application, a uniform density and adherence is obtained whenever Gunite is applied.

**For lining coal bunkers and steel chimneys** it possesses great resistance to corrosion and protects steel-work from the abrasive action of coal or coke.

**116, RICHMOND ROAD, KINGSTON-UPON-THAMES, SURREY**
KINGSTON 7883 & 9252

**10, ROYAL CRESCENT, GLASGOW C.3**
Telephone: GLASGOW DOUGLAS 8671

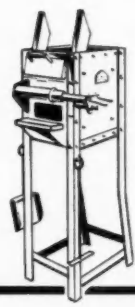
## THE CONCRETE PROOFING CO., LTD.

*Handbook "GUNITE" sent on request*

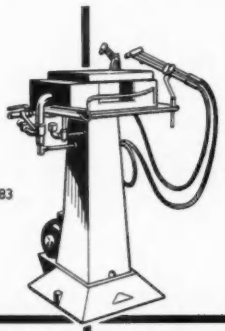
# Industrial Gas Equipment?

## A.H.WILKES & Co.
*of course!*

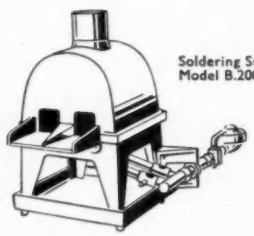
He knows that for Industrial Gas Equipment of the utmost efficiency and economy in operation he cannot do better than consult A. H. Wilkes & Co. With close on 50 years specialised experience in design and manufacture, we can advise on every industrial heating requirement. Let us know *your* particular problem—we will be pleased to assist you.



Brass Stamping Furnace. Model B.2183



PF.040 Furnace



Soldering Stove Model B.2004

**'ALCOSA'**
PRODUCTS INCLUDE:

*Blowers, Brazing equipment, Gas and Oil Burners, Fans, Furnaces, Portable Forges, Soldering and Tinsmith Equipment, etc.*

## A. H. WILKES & CO.
A SUBSIDIARY OF WILLIAM ALLDAY & CO. LTD.

*Head Office:* **"ALCOSA" WORKS, STOURPORT-ON-SEVERN, WORCS.**
**Telephone: Stourport 2311-4. Telegrams: 'Yadall', Stourport**

*London Area Office:*
**158 Birchanger Rd., S. Norwood, S.E. 25. Telephone: Addiscombe 1162 and 1295**